

The Claims

1. A light emitting device, comprising:
a semiconductor device that emits light having a wavelength in the range of 200 nm to 620 nm; and
a red phosphor comprising a vanadate combined with yttrium, gadolinium and/or lanthanum and activated with trivalent Eu^{3+} , Sm^{3+} and Pr^{3+} , or any combination thereof, with or without Tb^{3+} as a co-dopant.
2. The device of claim 1 in which the red phosphor absorbs light of a wavelength in the range of 240 nm to 550 nm and emits red light at a wavelength in the range of 580 nm to 700 nm.
3. The device of claim 1 containing at least one non- red phosphor in addition to said red phosphor.
4. The device of claim 1 containing a green phosphor and a blue phosphor in addition to said red phosphor.
5. The device of claim 1 in which said red phosphor has the formula:
$$\text{Bi}_x\text{Ln}_{1-x}\text{VO}_4\text{:A}$$
where $x = 0$ to 1 , Ln is an element selected from the group consisting of Y, La and Gd, and A is an activator selected from Eu^{3+} , Sm^{3+} and Pr^{3+} , or any combination thereof, with or without Tb^{3+} as a co-dopant.
6. The device of claim 5 in which x is greater than 0 and less than 1.
7. The device of claim 6 in which x is 0.05 to 0.5.
8. The device of claim 5 including Tb^{3+} as a co-dopant.
9. The device of claim 1 in which the semiconductor device is a GaN based device.

10. The device of claim 1 in which the semiconductor device is a vertical cavity surface emitting laser, a light emitting diode, or a laser diode.
11. The device of claim 10 in which the semiconductor device is a GaN based device.
12. The device of claim 11 in which the semiconductor device is a light emitting diode.
13. The device of claim 5 containing a green phosphor and a blue phosphor in addition to said red phosphor and in which said green phosphor is $\text{ZnS:Cu}^+, \text{Al}^{3+}$) and said red phosphor is $\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$.
14. A light emitting semiconductor device, comprising:
 - a GaN based light emitting diode that emits light having a wavelength in the range of 200 nm to 620 nm;
 - a red phosphor that absorbs light of a wavelength in the range of 240 nm to 550 nm and emits red light at a wavelength in the range of 580 nm to 700 nm, having the formula:

$$\text{Bi}_x\text{Ln}_{1-x}\text{VO}_4:\text{A}$$
 where x is 0.05 to 0.5, Ln is an element selected from the group consisting of Y, La and Gd, and A is an activator selected from Eu^{3+} , Sm^{3+} and Pr^{3+} , or any combination thereof, with or without Tb^{3+} as a co-dopant;
 - a green phosphor; and
 - a blue phosphor.
15. The device of claim 14 including Tb^{3+} as a co-dopant.
16. The device of claim 14 in which said green phosphor is $\text{ZnS:Cu}^+, \text{Al}^{3+}$) and said blue phosphor is $\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$.
17. A white light emitting phosphor combination, comprising:
 - a red phosphor comprising a vanadate combined with yttrium, gadolinium and/or lanthanum and activated with trivalent Eu^{3+} , Sm^{3+} and Pr^{3+} , or any

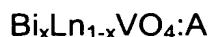
combination thereof, with or without Tb^{3+} as a co-dopant;

a green phosphor; and

a blue phosphor.

18. The phosphor combination of claim 17 in which said red phosphor absorbs light of a wavelength in the range of 240 nm to 550 nm and emits red light at a wavelength in the range of 580 nm to 700 nm.

19. The phosphor combination of claim 17 in which said red phosphor has the formula:



where $x = 0$ to 1 , Ln is an element selected from the group consisting of Y, La and Gd, and A is an activator selected from Eu^{3+} , Sm^{3+} and Pr^{3+} , or any combination thereof, with or without Tb^{3+} as a co-dopant.

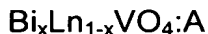
20. The phosphor combination of claim 19 in which x is greater than 0 and less than 1.

21. The phosphor combination of claim 20 in which x is 0.05 to 0.5.

22. The phosphor combination of claim 19 in which said red phosphor includes Tb^{3+} as a co-dopant.

23. The phosphor combination of claim 19 in which said green phosphor is $\text{ZnS}:\text{Cu}^+, \text{Al}^{3+}$) and said blue phosphor is $\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$.

24. A white light emitting phosphor combination,
a red phosphor that absorbs said light of a wavelength in the range of 240 nm to 550 nm and emits red light at a wavelength in the range of 580 nm to 700 nm, having the formula:

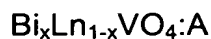


where x is 0.05 to 0.5, Ln is an element selected from the group consisting of Y, La and Gd, and A is an activator selected from Eu^{3+} , Sm^{3+} and Pr^{3+} , or any combination thereof, with or without Tb^{3+} as a co-dopant.;

a green phosphor comprising $\text{ZnS}:\text{Cu}^+, \text{Al}^{3+}$); and
a blue phosphor comprising $\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu}^{2+}$.

25. The phosphor combination of claim 24 in which said red phosphor includes Tb^{3+} as a co-dopant.

26. A red phosphor that absorbs said light of a wavelength in the range of 240 nm to 550 nm and emits red light at a wavelength in the range of 580 nm to 700 nm, having the formula:



where x is greater than 0 and less than 1, Ln is an element selected from the group consisting of Y, La and Gd, and A is an activator selected from Eu^{3+} , Sm^{3+} and Pr^{3+} , or any combination thereof, with or without Tb^{3+} as a co-dopant.

27. The phosphor 26 in which x is 0.05 to 0.5.

28. The phosphor 26 in which in which said red phosphor includes Tb^{3+} as a co-dopant.